Quantum, Space and Time--The Quest Continues, Studies and Essays in Honour of Louis de Broglie, Paul Dirac and Eugene Wigner by Asim O. Barut; Alwyn van der Merwe; Jean-Pierre Vigier
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difficult idea. Sometimes he spreads the words too thick; central points are sometimes swamped by digressions, elaborations, and subsidiary points, making it easy for one to lose one's way. But in general the writing is pleasing, and often witty. The book can be recommended to readers with some philosophical background who find the philosophy of language daunting, as well as to those already at home in the subject.

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[1] For serious doubts about the success of Blackburn's quasi-realist maneuvers, see Nicholas Sturgeon, "What Difference Does It Make Whether Moral Realism Is True?" (forthcoming).

Asim O. Barut, Alwyn van der Merwe and Jean-Pierre Vigier, eds., *Quantum, Space and Time—The Quest Continues, Studies and Essays in Honour of Louis de Broglie, Paul Dirac and Eugene Wigner*, (Cambridge: Cambridge University Press, 1984), vii + 662 pp.

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The 46 papers collected in this volume were first published in successive issues of *Foundations of Physics*, to celebrate the 90th birthday of Louis de Broglie (August 15, 1982) and the 80th birthdays of P.A.M.Dirac (August 8, 1982) and Eugene P. Wigner (November 11, 1982). Nearly all of them deal with fundamental questions of quantum physics, from diverse points of view. While the de Broglie *Festschrift* is mainly addressed to people who have had some education in mathematical physics but need not be proficient in any branch of it, many of the articles dedicated to Dirac and Wigner, including those by Nathan Rosen, Julian Schwinger, Yuval Ne'eman, Hai-Woong Lee and M.O.Scully, J.G. Taylor, E.C.G.Sudarshan and N.Mukunda, Feza Gürsey, A.O.Barut and J.Kraus, etc., are somewhat technical in scope and manner. On the other hand, the book contains a few papers of historical or broadly philosophical nature, such as G.Lochak's "The evolution of the ideas of Louis de Broglie on the interpretation of wave mechanics" (pp.11-33), and "Is physics at the threshold of a new stage of evolution?" by R.Rompe and H.J.Treder (pp.595-609), which are quite undemanding. All in all, this is a pretty variegated book, more so perhaps than most collective volumes of its kind, and it should give a diligent reader many hours of worthwhile entertainment.

Several contributions will, in my opinion, be of particular interest to philosophers of science. In the first place, I would like to mention Jean-

Marie Souriau's "Physics and geometry" (pp.376-94), a beautifully concise report on the uses of differential geometry "as the most appropriate language for the description of physical reality". The same point is further illustrated, with some detail, in the papers by Roger Penrose ("Spinors and tensors in general relativity", pp.574-88) and Hanno Rund ("Invariance identities associated with finite gauge transformations and the uniqueness of the equations of motion of a particle in a classical gauge field", pp.336-57), but these are among the more technical ones.

I also was enticed by Geoffrey F. Chew's "non-technical review" of a recent version of his bootstrap theory of elementary particles ("Bootstrapping the photon", pp.470-99). The goal of the bootstrap theory—as far as I am able to discern it—is to derive the properties of every class of so-called elementary particles from the universal *S*-matrix, i.e. from the infinite array of transition probabilities between all conceivable elementary particle inputs and outputs.[1] Since the conditions imposed on the *S*-matrix—viz. that it be unitary, analytic and Poincaré invariant—are, bootstrappers tell us, "required by our methods of observation", the bootstrap, if successful, would amount to a transcendental deduction of sorts, implying that, as Frithoj Capra boldly put it, "the observed patterns of matter are nothing but reflections of patterns of mind".[2] To an old Kant buff this sounds, of course, frightfully attractive. However, I must admit that after reading Chew's "Bootstrapping the photon" twice, while on the same day rereading the aforementioned article by Capra, I do not find myself any wiser with regard to the grounds, or even the actual physical meaning of the bootstrap theory. As with other theories of fundamental physics, so it must be the case with this one, that you cannot make head or tail out of it until you face it in its full formal regalia. Such an involvement would presumably demand several months of unremiting attention, which unfortunately is more than a non-physicist can afford to spend on a physical theory that has not yet scored any spectacular predictive success and is favored only by a small coterie.

Unorthodoxy in physics serves anyway as a useful reminder that science is a province of the human spirit, no less than art, religion or philosophy. In it, as elsewhere, monoliths of doctrine are usually artifacts—and instruments—of power (when they do not merely bear witness to a community's intellectual penury). A notorious scientific heresy that is fairly well represented in this book is the "pilot wave" version of quantum mechanics put forward in the 20's by de Broglie, withdrawn by him under the apparent weight of Wolfgang Pauli's objections at the 1927 Solvay conference, independently reinvented by David Bohm in the early 50's and subsequently furthered by de Broglie himself, Bohm, Jean-Pierre Vigier and others. The gist of it consists in taking a particle to be literally a pointlike object with a definite trajectory, while assuming that along with it there is a physically real wave satisfying Schrödinger's equation, at least as a linear approximation. The momentum $\mathbf{p}$ of the particle and the phase ϕ of the wave are linked by the equation $2\pi\mathbf{p} = h\nabla\phi$, which suggests that the particle is being guided by the wave, whence the epithet "pilot".

Bohm and Hiley, from whose contribution to the present volume, p.78, I draw the above hints, propose that we consider "the analogy of an airplane guided by radar waves, which carry information about the whole environment". Bohm's original papers of 1952 (*Phys.Rev.* 85:166-93; now reprinted in Wheeler and Zurek's *Quantum Theory and Measurement*, Princeton 1983) still provide a most clear and judicious exposition of the theory's core ideas and motivation; and Bohm's book, *Wholeness and the Implicate Order* (London 1980) spells out its philosophical implications for a broad audience. However, someone reaching for a quick and yet authoritative overview will find it here in the said article by Bohm and Hiley, "The de Broglie pilot wave theory and the further development of new insights arising from it" (pp.77-92), and in the richly suggestive essay by J.Andrade e Silva, "On the contribution of Louis de Broglie to the quantum theory of measurement" (pp.55-65). In other related papers, J.-P. Vigier, in collaboration with Ph. Gueret ("De Broglie's wave-particle duality in the stochastic interpretation of quantum mechanics: a testable physical assumption", pp.129-55) and with N.Cufaro Petroni ("Dirac's aether in relativistic quantum mechanics", pp. 505-38), makes some state-of-the-art contributions to the de Broglie-Bohm theory's current development; while J.S.Bell, of Bell-Inequality fame, defends its viability ("On the impossible pilot wave", pp.66-76), presenting it as a counterexample, in the strict logical sense, to alleged proofs (proposed by von Neumann, by Specker, Gleason and Jauch, and by Jost) that standard quantum mechanics cannot be conceived as the statistical phenomenology of some as yet unknown deterministic infrastructure.

I have not kept an eye on misprints, but I could not help noticing the following two, on page 57: at the end of line 15, "ϕ_k" ought to be "χ_k"; at the end of line 20, the exponent "4" should read "2".

NOTES

[1] During its early stage, about 1960, the theory referred only to hadrons (i.e. particles liable to so-called strong interactions). Speaking of that stage, Andy Pickering explains the idea of bootstrapping as follows: "Consideration of the analytic structure of the *S*-matrix led to an infinite set of coupled non-linear differential equations. No one knew how to solve this set of equations exactly . . . but Chew proposed that it did have a solution; that the solution was unique; and that, through the requirement of self-consistency, it determined all of the properties of all the hadrons. If this were the case, the general properties of the *S*-matrix determined *everything* about hadrons . . . Chew described his approach as 'democratic'—since all of the hadrons, stable and unstable, were supposed to pull themselves up by their own bootstraps as a self-consistent solution to the *S*-matrix equations." (Pickering, *Constructing Quarks*, Chicago 1984, p.74.)

[2] Frithoj Capra, "Quark physics without quarks,' *American Journal of Physics* 47 (1979):11-23.